JP ... P 12 (2)

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CLAIMS

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(57) [Claim(s)]
[Claim 1]An optical system characterized by comprising the following for carrying out reduction projection of the pattern of the 1st page on the 2nd page.
The 1st lens group that has negative or positive refracting power, and spreads or converges said light flux from the 1st page.
A half mirror which penetrates or reflects light flux from this 1st lens group.
The 2nd lens group that extends light flux reflected from said half mirror with negative refracting power.
Lieberkuhn which returns light flux from this 2nd lens group to said half mirror via this 2nd lens group converging, The 3rd lens group that converges light flux which was returned to said half mirror with positive refracting power, and penetrated said half mirror, and forms a reduced image of said pattern of the 1st page on said 2nd page, and a diaphragm arranged between said half mirror and said 2nd page.

[Claim 2]The reflective refraction reduction projection optical system according to claim 1 having arranged a plane-parallel plate of one sheet or two or more sheets for amending aberration which originates in said half mirror aslant to an optic axis between said half mirror and said 3rd lens group.
[Claim 3]Claim 1 being 25 times the curvature radius of said lieberkuhn of this from 17 times of a diameter of an exposure region on said 2nd page, or a reflective refraction reduction projection optical system given in two.
[Claim 4]Claim 1, wherein inclination to an optic axis of a marginal ray from an axial choice-goods point which penetrates said half mirror is 0.1 degree or less, or a reflective refraction reduction projection optical system given in two.
[Claim 5]Claim 1, wherein inclination to an optic axis of a chief ray outside an axis which enters into said lieberkuhn is 4 times or less, or a reflective refraction reduction projection optical system given in two.

[Claim 6]Claim 1 having arranged 1/4 wavelength plate between said half mirror and said lieberkuhn, or a reflective refraction reduction projection optical system given in two.

[Claim 7]The reflective refraction reduction projection optical system according to claim 6, wherein thickness forms said 1/4 wavelength plate from 1 axial crystal of 100 micrometers or less.

[Claim 8]It is the exposure device provided with a reflective refraction reduction projection optical system of claim 1-7 given in any 1 paragraph, An exposure device having an illumination-light study system which illuminates reticle arranged at said 1st page, and transferring a reduced image of a pattern of said reticle on a wafer arranged via said reflective refraction reduction projection optical system at said 2nd page.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application]This invention is applied to the optical system for carrying out reduction projection of the pattern expanded rather than the pattern of the real element used for the exposure device for semiconductor device manufacture, for example, and relates to a suitable reflective refraction reduction projection optical system.

[0002]

[Description of the Prior Art]Minuteness making of the integrated circuit is carried out increasingly, and, as for the exposure device which prints the pattern, what has higher resolution is demanded. In order to fill this demand, short wavelength formation of the wavelength of a light source must be carried out, and the numerical aperture (N.A.) of an optical system must be enlarged. However, if wavelength becomes short, the ** material which is equal to practical use for the absorption of light will be restricted. If wavelength is set to 300 nm or less, it will become only synthetic quartz and fluorite (calcium fluoride) that it can use practically. Temperature characteristics cannot use fluorite so much bad. Therefore, it is very difficult to make a projection lens only from refractive media. It is also difficult to make a projection optical system with a large numerical aperture only from a reflection system for the difficulty of aberration compensation.

[0003]Then, the art which constitutes a projection optical system combining a reflection system and refractive media is proposed variously. The example is a **** ring view optical system indicated by JP,63-163319,A. The light flux besides an axis is used so that incident light and catoptric light may not interfere mutually, and it

comprises this optical system so that only the zona-orbicularis part besides an axis may be exposed.

[0004]The projection aligner which consists of reflective refractive media which project the image of reticle (mask) by package according to the light flux on an axis is indicated, for example by JP,51-27116,B and JP,2-66510,A by arranging a beam splitter in a projection optical system as other examples.

[0005]Drawing 5 shows typically the optical system indicated by JP,2-66510,A. In this drawing 5, the light flux from the reticle 21 on which the pattern which is going to carry out reduction transfer was drawn is changed into abbreviated ********** by the lens group 22 which has positive refracting power, and it is irradiated with it by the prism type beam splitter (beam splitter cube) 23. The light flux which penetrated the plane of composition 23a of this beam splitter 23 is diffused by the correcting lens group 24 which has negative refracting power, and is reflected in the lieberkuhn 25. After the light flux reflected in the lieberkuhn 25 passes along the correcting lens group 24 again and being reflected in the plane of composition 23a of the beam splitter 23, it converges on the wafer 27 and image formation of the reduced image of a reticle pattern is carried out on the wafer 27 by the lens group 26 which has positive refracting power. The example using the half mirror which consists of plane-parallel plates instead of the prism type beam splitter 23 is also indicated.

[0006]

[Problem(s) to be Solved by the Invention]However, it is difficult to enlarge a numerical aperture by a ring view optical system among conventional examples. And it needed to expose moving reticle and a wafer at a mutually different speed corresponding to the reduction ratio of an optical system, since it could not expose by package, either, and there was inconvenience that the composition of a mechanical system became complicated for this reason.

[0007]In the composition indicated by above-mentioned JP,51-27116,B, there is inconvenience with much flare by reflection by the refracting interface of the optical system after a beam splitter. Since the characteristics, such as reflectance unevenness of a beam splitter, absorption, and a phase change, are not taken into consideration at all, resolution is low, and the magnification of the whole system is actual size, and use is not borne at all as a next-generation exposure device for semiconductor manufacture with which high resolving power is demanded more.

[0008]By the optical system of drawing 5, there is inconvenience in which resolution deteriorates by the unevenness of the large-sized prism material for the beam splitters 23 among the projection optical systems indicated by JP,2-66510,A. In a wavelength band of about 300 nm or less, there are no adhesives which are equal to use, and there is inconvenience that it is difficult to paste two blocks together and to constitute a beam splitter. In the projection optical system, the position of the diaphragm was one of the positions which lap with the beam splitter 23 or a half mirror,

and there was inconvenience which cannot place a diaphragm physically. By this, resolution deteriorated, and amendment of the unevenness of light volume was not completed, and also tele centric nature by the side of the wafer 27 could not be secured, and it was not practical as a semiconductor aligner.

[0009]This invention is the composition using the light flux on an axis in view of this point in reflective refractive media. Resolution does not deteriorate and the purpose is to provide the reduction projection optical system which can arrange a diaphragm.

An object of this invention is also to provide the exposure device provided with such a reduction projection optical system. [0010]

[Means for Solving the Problem]A reflective refraction reduction projection optical system by this invention is an optical system for carrying out reduction projection of the pattern of the 1st page (1) on the 2nd page (5), as shown, for example in drawing 1, 1st lens group G_1 which has negative or positive refracting power, and spreads or converges the light flux from the 1st page (1), A half mirror (2) which penetrates or reflects light flux from this 1st lens group G_1, 2nd lens group G_2 which extends light flux reflected from the half mirror (2) with negative refracting power, Lieberkuhn (4) which returns light flux from this 2nd lens group G_2 to that half mirror (2) via this 2nd lens group G_2 converging, 3rd lens group G_3 which converges light flux which was returned to the half mirror (2) with positive refracting power, and penetrated the half mirror (2), and forms a reduced image of the pattern of the 1st page (1) on the 2nd page (5), They are the half mirror (2) and a thing which have been arranged between the 2nd page (5) and which extracts and has (6).

[0011]Arranging a plane-parallel plate of one sheet or two or more sheets for amending aberration which originates in the half mirror (2) aslant to an optic axis between the half mirror (2) and its 3rd lens group G_3 is also considered.

[0012]It is preferred to set up a curvature radius of the lieberkuhn (4) within the limits of 17 to 25 times of a diameter of an exposure region (image circle) on the 2nd page (5) in these cases. As for inclination to an optic axis of a marginal ray from an axial choice-goods point which penetrates the half mirror (2), it is preferred that it is 0.1 degree or less. As for inclination to an optic axis of a chief ray outside an axis which enters into the lieberkuhn (4), it is preferred that it is 4 times or less.

[0013]It is preferred to arrange 1/4 wavelength plate (3) between the half mirror (2) and its lieberkuhn (4) in this invention. The 1/4 wavelength plate (3) is good for thickness to form from 1 axial crystal (for example, crystal) of 100 micrometers or less. Next, an exposure device by this invention is an exposure device provided with a reflective refraction reduction projection optical system by this invention, It has an illumination-light study system which illuminates reticle (1) arranged at the 1st page, and a reduced image of a pattern of the reticle is transferred on a wafer (5) arranged via the reflective refraction reduction projection optical system at the 2nd page.

[0014]

[Function]According to this this invention, in order to expose a large field by package with the composition which combined a reflection system and refractive media, the light flux on an axis is used. Since there is no chromatic aberration in a reflection system, the great portion of refracting power of the whole system is given to the lieberkuhn (4), and generating of a chromatic aberration is suppressed. And a half mirror (2) performs separation with incident light and catoptric light. It is because profile irregularity may be [that big ** material is unnecessary, that are a simple substance and adhesives are unnecessary, and] bad by a refractive index to use a half mirror as compared with a prism type beam splitter.

[0015]However, astigmatism and a coma aberration occur by using a half mirror (5). In order to prevent it, it is necessary to make into a parallel beam thoroughly light flux which penetrates a half mirror (5). However, it is impossible to realize a perfect parallel pencil to all the image height. So, in this invention, the light flux which diffused or converged by 1st lens group G_1 is reflected by a half mirror (2), and the influence of a half mirror (2) is excluded. And he brings the converged beam reflected from the lieberkuhn (4) close to a parallel pencil by 2nd lens group G_2 of negative refracting power, and is trying for the light approaching this parallel pencil to penetrate a half mirror (2). Therefore, generating of the astigmatism in a half mirror (2) and a coma aberration is controlled.

[0016]Although the light flux which penetrates the half mirror (2) is abbreviated **********, generally an aperture diaphragm is placed by the position from which the light ejected from the object point became abbreviated **********. Therefore, according to the composition of this invention, the half mirror (valid diaphragm (5 between 2) and the 2nd page (5)) can be arranged.

[0017]Although 2nd lens group G_2 which has negative refracting power between a half mirror (2) and the lieberkuhn (4) is arranged in this invention, This 2nd lens group G_2 can amend the chromatic aberration of 3rd lens group G_3 of positive refracting power, and the spherical aberration of the lieberkuhn (4) can be amended more to fitness. As described above, 2nd lens group G_2 of this negative refracting power has the important role of bringing the light flux which penetrates a half mirror (2) close to a parallel beam.

[0018]Next, in order to control more effectively the astigmatism and coma aberration resulting from the half mirror (2). After bringing close to a parallel pencil as much as possible and making a coma aberration small enough, it is good to lean and insert the plane-parallel plate of one sheet to an optic axis between a half mirror (2) and 3rd lens group G_3. Astigmatism is also amended by leaning 45 degrees of plane-parallel plates of thickness equal to a half mirror (2) to an optic axis, and rotating 90 degrees of directions of the plane-parallel plate to the direction of a half mirror (2) especially. If the plane-parallel plate of three sheets of thickness equal to a half mirror (2) is used, even when the light flux which penetrates a half mirror (2) is not abbreviated

**********, astigmatism and a coma aberration can be amended. That is, 45 degrees of plane-parallel plates of three sheets are leaned to an optic axis, respectively, and these astigmatism and a coma aberration are thoroughly amended by setting up make the angle of 90 degrees, 180 degrees, and 270 degrees to the direction of a half mirror (2), respectively.

[0019]Next, the curvature radius of the lieberkuhn (4) explains the reason 25 times are preferred, from 17 times of the diameter of the exposure region (image circle) on the 2nd page (5). In the lieberkuhn, the astriction can attain a certain amount of reducing magnification, and. Since the PETTSU bar sum, astigmatism, and a distortion aberration are affected, it becomes possible to maintain aberration balance with the refractive media which consist of 1st lens group G_1, 2nd lens group G_2, and 3rd lens group G_3 good. That is, when the curvature radius of the lieberkuhn (4) is less than 17 times of the diameter of the image circle of the 2nd page (5), it becomes advantageous to amendment of a chromatic aberration, but the PETTSU bar sum increases for Masakata and also increases astigmatism and a distortion aberration.

[0020]If the curvature radius of the lieberkuhn becomes small and refracting power becomes large, the spherical aberration by the lieberkuhn (4) will become large, but the reason. Since the refracting power of negative 2nd lens group G_2 in order to make into a parallel pencil light flux which penetrates a half mirror (2) becomes large, in order to be amendment of a spherical aberration, it is necessary to enlarge positive refracting power of 3rd lens group G_3. However, since 3rd lens group G_3 is arranged at the position near the 2nd page (5) as the image surface, the big refracting power beyond the negative refracting power of 2nd lens group G_2 for aberration compensation will be needed, and the PETTSU bar sum will increase remarkably. Therefore, as for the curvature radius of the lieberkuhn (4), in order to amend several aberration still better, it is preferred that they are about 17 or more times of the diameter of the image circle of a reduced image.

[0021]On the contrary, when the curvature radius of the lieberkuhn (4) becomes large exceeding 25 times of the diameter of the image circle of a reduced image, it becomes advantageous to amendment of astigmatism and a distortion aberration, but since it becomes difficult to obtain desired reducing magnification and it becomes insufficient amending it of a chromatic aberration, it is not so practical.

[0022]Next, a reason with preferred the inclination to the optic axis of the marginal ray (what is called a land beam of light) from the axial choice-goods point which penetrates a half mirror (2) being 0.1 degree or less is explained. As mentioned above, generating of the aberration resulting from a half mirror (2) is controlled so that the light flux which penetrates a half mirror (2) is close to a parallel pencil, and it becomes easy to arrange a diaphragm. In particular, when the maximum of the gap from the parallel pencil is 0.1 degree or less, an aberration amount is practical few.

[0023]A reason with preferred the inclination to the optic axis of the chief ray outside

an axis which enters into the lieberkuhn (4) being 4 times or less is explained. That is, if inclination of the chief ray outside an axis is not restricted in this way, the astigmatism in the lieberkuhn (4), etc. will become large too much. Therefore, generating of the aberration which restricts the inclination to an optic axis to 4 times or less, and originates in the lieberkuhn (4) is controlled, and image formation performance is raised as a whole.

[0024]1/4 wavelength plate (3) is explained per operation effect in the case of having arranged between a half mirror (2) and the lieberkuhn (4). general -- half a half mirror -- ** -- a field -- ****** -- a strong polarization characteristic is among the dielectric films used -- a half mirror -- (-- half 2) -- ** -- a field (2a) -- **** -- for example, suppose that it is easy to penetrate the light flux (p-polarized light) which polarized in parallel with the space of drawing 1 that the light flux (s-polarized light) which polarized at right angles to the space of drawing 1 is easy to be reflected. in this case -- the -- a half -- the s-polarized light ingredient reflected in respect of ** (2a) penetrates 1/4 wavelength plate (3), and serves as circular light, it is reflected in the lieberkuhn (4) and the light flux of this circular light serves as circular light of the circumference of reverse. the catoptric light of the circular light of the circumference of reverse turns into p-polarized light by penetrating 1/4 wavelength plate (3) -- the light flux of this p-polarized light -- most -- a half mirror -- (-- half 2) -- ** -- a field (2a) -- it penetrates and goes to the 2nd page (5). Therefore, it not only can reduce the loss of the light volume in a half mirror (2) with the 1/4 wavelength plate (3), but since excessive catoptric light becomes difficult to return to the 2nd page (5), it can reduce flare.

[0025]It is desirable to use 1 axial crystal with thin thickness (for example, crystal) as 1/4 wavelength plate (3). The reason is for astigmatism to arise to an extraordinary ray, when the light flux which penetrates 1/4 wavelength plate shifts from a parallel pencil. This astigmatism cannot be amended by the method of rotating the 90-degree optical axis of each other, and pasting the crystal of two sheets together as usually performed by the wavelength plate. That is, astigmatism will produce an ordinary ray and an extraordinary ray.

[0026]As what expresses this astigmatic quantity with the wavefront aberration W, in (n_o-n_e), when the difference of the refractive index of an ordinary ray and an extraordinary ray and d are made into the thickness of a crystal and theta is made into the gap from a parallel beam, i.e., the emission (or convergence) angle of light flux, the wavefront aberration W is expressed with a following formula.

In constituting $1/W=(n_o-n_e)$ dtheta^2/2, for example, 4, wavelength plate from crystal, it shall be $=(n_o-n_e)$ 0.01 and the emission (convergence) state of light flux shall be theta= 15 degrees. When a using wavelength is set to lambda, in order to maintain sufficiently good image formation performance, it is preferred to maintain the wavefront aberration W to 1/4 wave, i.e., [less than lambda/4]. For that purpose, the

wavelength lambda must be 248 nm and it must be d< 100 micrometers from the above-mentioned formula.

[0027]

[Example]Hereafter, with reference to drawing 1 - drawing 4, I will explain per example of the reflective refraction reduction projection optical system by this invention. As for this example, in the using wavelength for semiconductor manufacture, reducing magnification applies this invention to the optical system of one fifth of exposure devices at 248 nm. Drawing 1 shows the composition of the outline of the optical system of this example, and 1 is the reticle in which the pattern for integrated circuits was formed in this drawing 1. The half mirror 2 inclined [on the optic axis vertical to this reticle 1] 45 degrees to 1st lens group G_1 and the optic axis which have negative or positive refracting power in order is arranged. and the light from 1st lens group G_1 -- half half mirror 2 -- in order in the direction reflected by ** side 2a, the catoptric light arrange 2nd lens group G_2 and the lieberkuhn 4 with the 1/4 wavelength plate 3 and negative refracting power, and according to the lieberkuhn 4 -- half half mirror 2 -- 3rd lens group G_3 and the wafer 5 which have the diaphragm 6 and positive refracting power in the direction penetrated by ** side 2a in order are arranged. The diaphragm 6 can also be put in for example, 3rd lens group G_3.

[0028]In this case, aberration, such as astigmatism, will be produced, if it has shifted from the parallel pencil even when the light flux which penetrates the half mirror 2 is slight. So, when the demand to aberration is severe, the light flux which penetrates the half mirror 2 first is brought close to a parallel pencil, and a coma aberration is made small enough. And to an optic axis, 45 degrees of plane-parallel plates of thickness equal to the half mirror 2 are leaned between the half mirror 2 and 3rd lens group G_3, and are arranged, and 90 degrees of the direction is rotated to the direction of the half mirror 2. Thereby, astigmatism is amended. Even when the light flux which penetrates the half mirror 2 when the plane-parallel plate of three sheets is used has separated from the parallel pencil, astigmatism and a coma aberration can be amended.

[0029]And it illuminates by the illumination-light study system which carried out the graphic display abbreviation of the reticle 1, and it spreads or converges by the 1st lens group G1, and the light flux ejected from the reticle 1 is entered in the half mirror 2. half this half mirror 2 -- the light flux reflected by ** side 2a is entered in the lieberkuhn 4 via 2nd lens group G_2 of the 1/4 wavelength plate 3 and negative refracting power. The curvature radius of the lieberkuhn 4 is about 400 mm. the light flux reflected by the lieberkuhn 4 enters into the half mirror 2 again through 2nd lens group G_2 and the 1/4 wavelength plate 3, converging -- half this half mirror 2 -- the light flux which penetrated ** side 2a is converged on the wafer 5 by 3rd lens group G_3 of positive refractive power. Thereby, image formation of the reduced image of the pattern on the reticle 1 is carried out on the wafer 5.

[0030]Although it extracts between the half mirror 2 and 3rd lens group G_3 and 6 is

arranged in this example, the tele centric nature by the side of the wafer 5 is secured by this diaphragm 6.

[0031]Although it is efficient to use the light flux (s-polarized light) which polarized at right angles to the space of drawing 1 as illumination light, the illumination light of the ordinary random polarization may be sufficient. any case -- the polarization characteristic of the half mirror 2 -- half the great portion of s-polarized light -- being reflected by ** side 2a -- this catoptric light -- further -- it becomes circular light by penetrating the 1/4 wavelength plate 3. Although the light flux of this circular light is reflected in the lieberkuhn 4 and it becomes the circular light of the circumference of reverse, if the light flux of the circular light of the circumference of reverse penetrates the 1/4 wavelength plate 3 again, a polarization condition will serve as linear polarization parallel to the space of drawing 1. the light flux which polarized in the direction parallel to the space of drawing 1 with the polarization characteristic of the half mirror 2 -- half most -- ** side 2a is penetrated and it goes in the direction of the wafer 5. Since reduction of the light in the half mirror 2 is prevented by this and the returned light to the reticle 1 decreases, effective use of light flux and reduction of the flare are attained.

[0032]Astigmatic generating is prevented by using 1 axial crystal with thin thickness (for example, crystal) as the 1/4 wavelength plate 6. Concretely, in order to suppress the wavefront aberration by the 1/4 wavelength plate 6 to less than lambda/4 at 248 nm, the using wavelength lambda needs to set thickness of the 1/4 wavelength plate 6 to 100 micrometers or less, noting that crystal is used.

[0033]half half mirror 2 -- if a polarization characteristic like a polarization beam splitter is positively given to ** side 2a, reflectance and transmissivity are further improvable with combination with the 1/4 wavelength plate 6. However, even if it is the usual half mirror, since a dielectric film has a strong polarization characteristic, it can improve reflectance and transmissivity with combination with the 1/4 wavelength plate 3, for example.

[0034]Hereafter, it explains per concrete example of composition of the optical system of drawing 1. Since the shape and the interval of a lens in the following examples are expressed, reticle 1 is made into the 1st page and the field through which it will pass by the time the light ejected from the reticle 1 reaches the wafer 5 is made into the i-th page (i= 2, 3, ...) one by one. And between the reticle 1 and the half mirror 2, the numerals of curvature-radius r_i of the i-th page just take the case of a convex to the reticle 1, and just take the case of a convex to the lieberkuhn 4 between the lieberkuhn 4 and the wafer 5. the numerals of spacing d_i of the i-th page and a ** (i+1) side -- half half mirror 2 -- in the field through which the catoptric light from ** side 2a passes to the lieberkuhn 4, it just takes in other fields for negative. As ** material, CaF_2 expresses fluorite and SiO_2 expresses silica glass, respectively. The refractive index to the criteria-for-use-of-food-additives wavelength (248 nm) of

silica glass and fluorite is as follows.

Silica glass: 1.50855 fireflies Stone : 1.46799 [0035]As drawing 2 shows the lens constitution figure of this example and shows it to this drawing 2, 1st lens group G_1 sequentially from the reticle 1 side, Negative meniscus lens L_{11} which turned the convex to the reticle 1 side, biconvex lens L_{12}, biconvex lens L_{13}, biconcave lens L_{14}, and biconcave lens L_{15} are arranged and constituted. 2nd lens group G_2 consists of these examples only from negative meniscus lens L_{20} which turned the convex to the lieberkuhn 4 side. 3rd lens group G_3 sequentially from the half mirror 2 side Biconvex lens L_{31}, Positive meniscus lens L_{32} which turned the convex to the half mirror 2 side, Positive meniscus lens L_{33} which turned the convex to the half mirror 2 side, Biconcave lens L_{34}, biconvex lens L_{35}, positive meniscus lens L_{36} that turned the convex to the half mirror 2 side, Positive meniscus lens L_{38} which turned the convex to the negative meniscus lens L_{37} [which turned the convex to the half mirror 2 side], and half mirror 2 side is arranged and constituted. However, since thickness can disregard thinly the 1/4 wavelength plate 3 in drawing 1, it has omitted in drawing 2. Curvature-radius r_i in the 1st example, spacing d_i, and the ** material of drawing 2 are shown in the next table 1.

[0036]

[Table 1]

i $r_i d_i$ ** material i $r_i d_i$ ** material 1infinity160.328 21 -3775.726 8.500 2 226.290 20.000 $CaF_2$22 132.037. 20.000 $CaF_2$3 112.740. 12.000 23 386.661 80.662. 4 186.919 28.000 $SiO_2$24. 90.751 16.727 $CaF_2$5. -267.368 48.845 25 1020.086. 4.600 6 203.766 30.000. $SiO_2$26 -378.373. 11.000 $SiO_2$7 -153.468. 2.000 27 51.955 0.400. 8 -235.200 15.000 $CaF_2$28. 51.881 19.000 $CaF_2$9. 105.304 45.805 29 -402.490. 0.20010 -154.442 18.000 $CaF_2$30 66.487 11.242 $CaF_2$11 661.852 128.795 31 383.884 1.00012 infinity. -85.500 32 580.000 10.000. $SiO_2$13 156.613 -24.000. $SiO_2$33 39.378 1.60014. 303.843 -34.000 34 43.274. 13.000 $CaF_2$15 425.644. 34.000 35 514.049 14.38116. 303.843 24.000 $SiO_2$17 20.000 CaF_2 156.613 85.500 18 infinity 20.000 SiO_2 19infinity60.00020 296.017[0037]In this example, the diameter d of reducing magnification of the exposure region (image circle) effective [1/5 and a numerical aperture] on 0.45 and the wafer 5 is 20 mm. The curvature radius r of the lieberkuhn 4 is 425.664 mm, and the curvature radius r is about 21.3 times the diameter d. The maximum of the inclination to the optic axis of the chief ray outside an axis with which the maximum of the inclination to the optic axis of the marginal ray (land beam of light) from the axial choice-goods point which enters into the lieberkuhn 4 enters into 7.85 degrees and the lieberkuhn 4 is 2.41 degrees. Incidentally, the maximum of the inclination to the optic axis of the land beam of light ejected from the lieberkuhn 4 is 0.014 degree. The inclination to the optic axis of the land beam of light which penetrates the half mirror 2 is 0.001 degree or less, and it can be mostly considered in this example that the light flux which penetrated the half mirror 2 is a parallel pencil.

[0038]A longitudinal aberration figure in case the using wavelength of the example of drawing 2 is 248.4 nm is shown in drawing 3, and a transverse aberration figure is shown in drawing 4. Although a numerical aperture is as larger as 0.45 in this example than these aberration figure, it turns out that several aberration is amended good in the field of a large image circle. ** and the chromatic aberration which carry out a graphic display abbreviation are also amended good, while the wavelength lambda is 248 nm - 249 nm.

[0039]As for this invention, it is needless to say that various composition can be taken in the range which is not limited to the above-mentioned example and does not deviate from the gist of this invention.

[0040]

[Effect of the Invention]According to this invention, since the half mirror is used, degradation of the resolution by the unevenness of a large-sized prism material is not produced. Since he is trying to make a half mirror penetrate after bringing the light flux from the lieberkuhn close to a parallel pencil by the 2nd lens group of negative refracting power, there is little generating of the aberration by a half mirror. Therefore, as a whole, there is little degradation of resolution, and since it is close to a parallel pencil, there is an advantage which can arrange a diaphragm. When the plane-parallel plate of one sheet or two or more sheets has been arranged between a half mirror and the 3rd lens group, the aberration by the half mirror can be amended more to fitness.

[0041]From 17 times of the diameter of the exposure region whose curvature radius of the lieberkuhn is the 2nd page, when it is 25 times, astigmatism and a distortion aberration can be amended easily, and there is an advantage which is easy to obtain predetermined reducing magnification. When the inclination to the optic axis of the marginal ray from the axial choice-goods point which penetrates a half mirror is 0.1 degree or less, the coma aberration and astigmatism by a half mirror become small enough. When the inclination to the optic axis of the chief ray outside an axis which enters into the lieberkuhn is restricted to 4 degrees or less, aberration amounts, such as astigmatism, can be stopped in a prescribed range, and there is an advantage which can stop dispersion in the reflectance in a half mirror and transmissivity.

[0042]When 1/4 wavelength plate has been arranged between a half mirror and the lieberkuhn, the transmissivity in a half mirror can be raised and the flare can be decreased. When thickness forms especially the 1/4 wavelength plate from 1 axial crystal of 100 micrometers or less, there is an advantage which becomes to such an extent that astigmatic degradation can be disregarded. Since the reflective refraction reduction projection optical system by which aberration is suppressed low is used according to the exposure device of this invention, there is an advantage which can transfer the pattern image of reticle on a wafer in high resolution.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1]It is a sectional view showing the fundamental composition of the example of the reflective refraction reduction projection optical system by this invention.

[Drawing 2]It is a lens constitution figure showing the concrete composition of the optical system of drawing 1.

[Drawing 3]It is a longitudinal aberration figure of the example of drawing 2.

[Drawing 4]It is a transverse aberration figure of the example of drawing 2.

[Drawing 5]It is a sectional view showing the fundamental composition of the conventional reflective refraction reduction projection optical system.

[Description of Notations]

1 Reticle

The 1st lens group of G_1

2 Half mirror

3 1/4 wavelength plate

The 2nd lens group of G_2

4 Lieberkuhn

The 3rd lens group of G_3

5 Wafer